RATOTECKI

A Financial Modeling Approach to Maintenance Strategy: Quantifying Reliability ROI

A Case Study on TCO Reduction through Simulation-Based Decision Making

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Executive Summary

Industrial organizations face increasing pressure to reduce operating costs while maintaining asset availability. Maintenance budgets are often scrutinized because their financial return is difficult to quantify, leading to inefficient Preventive Maintenance (PM) programs and reactive firefighting. Industry analyses and reliability research suggest that a significant portion of traditional Preventive Maintenance (PM) activities may provide limited value when not aligned with actual failure modes or asset condition, with some reports indicating that a substantial share of PM tasks can be unnecessary or poorly timed relative to real failure risk [1][2][3].

This paper presents a simulation-based financial analysis conducted for a leading North American CPG (Consumer Packaged Goods) company in late 2025. All financial values are expressed in Canadian Dollars (CAD) unless otherwise noted. Using the Jingongo Financial Simulation Platform, we analyzed **nearly a decade** of maintenance data for a critical production asset to answer a single question:

What maintenance strategy minimizes Total Cost of Ownership (TCO) while preserving operational reliability?

The analysis identified an optimized strategy capable of reducing asset TCO by approximately 83%, delivering significant six-figure (CAD) annual savings and reclaiming **well over one thousand hours** of productive time annually. This paper outlines the methodology, results, limitations, and implementation plan behind that conclusion.

1. Industry Context & Problem Definition

Maintenance is one of the largest controllable operating expenses in industrial environments. However, its return on investment is difficult to measure because costs are visible while avoided failures are not. As a result, many organizations rely on historically inherited PM schedules rather than evidence-based reliability strategies.

In this case, the client experienced:

- High unplanned downtime despite significant PM labor investment
- Frequent emergency repairs on critical systems
- Limited financial visibility into maintenance decisions

The objective of this engagement was to replace intuition-driven maintenance planning with a **quantified, simulation-based financial decision framework**.

2. Methodology Overview

The Jingongo platform follows a structured four-step process designed to transform historical maintenance data into actionable financial decisions.

Step 1: Diagnose — Failure Mode Concentration

We ingested **nearly a decade** of historical work-order data from the client's maintenance system and applied a rules-based classification engine to normalize failure descriptions. The analysis revealed a strong concentration of cost and downtime:

- **65% of total emergency repair cost** was driven by two failure modes:
    - Electrical systems
    - Mechanical drivetrain

Further analysis showed that the existing PM program consumed **274 labor hours annually** yet had **no statistically measurable impact** on preventing these dominant failure modes. This misalignment was identified as the primary source of inefficiency.

Step 2: Model — Reliability Digital Twin

A reliability digital twin of the asset was constructed, modeling five primary failure modes as independent components. Each component was calibrated using historical Mean Time Between Failures (MTBF), converted to a failure rate (λ), and modeled using an **exponential distribution**.

The exponential model was selected based on historical failure interval analysis, which showed no statistically significant wear-out behavior for the aggregated components. This assumption is appropriate for random, memoryless failure processes and was validated through goodness-of-fit testing.

Step 3: Test — Monte Carlo Simulation

For each candidate maintenance strategy, **10,000 Monte Carlo simulations** were executed using a discrete-event simulation engine. Each simulation forecasted:

- Planned maintenance events
- Random failure events
- Repair labor and material costs
- Planned and unplanned downtime

This approach captures the probabilistic nature of failures rather than relying on average-based estimates.

Step 4: Decide — Financial Comparison

Strategies were compared using **Total Cost of Ownership (TCO)**, defined as the sum of:

- Emergency repair labor and parts
- Planned maintenance labor
- Downtime cost from lost production

Downtime cost was valued at **$500/hour**, based on client-provided throughput and contribution margin data.

3. Simulation Results

Projected 12-Month Financial Performance

Strategy	Emergency Repair Cost (CAD)	Planned PM Cost (CAD)	Downtime Cost (CAD)	Total Cost of Ownership (CAD)
Run-to-Failure	~$5,300	$0	~$180,000	**~$185,300**
Current PM Strategy	~$5,300	~$27,500	~$162,000	**~$194,800**
Optimized Strategy (Jingongo)	~$3,600	~$11,500	~$18,000	**~$33,100**

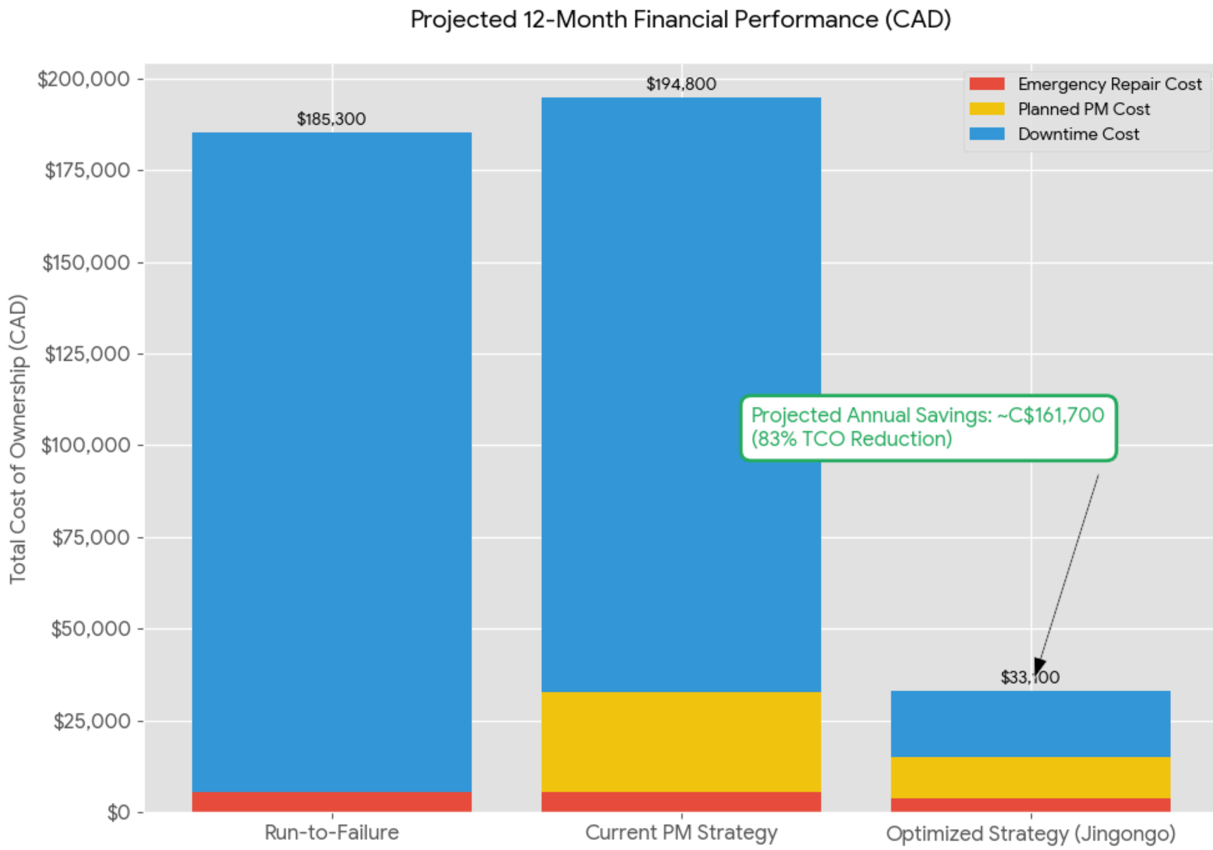

Figure 1: Projected 12-Month Financial Impact. ***Comparison of maintenance strategies showing the path to ~ $161,700 in annual savings.***

Projected Annual Savings (Optimized vs. Current): ~$161,700 (≈83% TCO reduction)

Downtime costs include maintenance execution time, line shutdown and restart cycles, and operational coordination delays.

4. Key Insights

1. Run-to-Failure Is Financially Unsustainable

While emergency repair costs appear modest, unplanned failures generated approximately **360 hours of downtime annually**, dominating total cost. The unpredictability of failures leads to extended diagnosis, expedited parts procurement, and prolonged production recovery.

2. Traditional PM Can Be Worse Than No PM

The existing PM program reduced neither failure frequency nor downtime for the asset's dominant failure modes. Instead, it introduced **324 hours of planned downtime annually**, consuming resources without reducing risk. In financial terms, the strategy performed worse than run-to-failure.

3. Targeted Proactive Intervention Delivers Outsized Returns

The optimized strategy replaces a broad PM program with a **single proactive drivetrain replacement** at **80% of historical MTBF (~1,440 hours)**. Electrical failures, which exhibited non-age-related behavior, were addressed through rapid response and spares strategy rather than time-based replacement.

This targeted approach:

- Prevents ~70% of high-impact drivetrain failures
- Reduces emergency downtime from ~360 hours to ~16 hours annually
- Limits planned downtime to ~36 hours annually

The result is a **10:1 return** on planned maintenance investment.

5. Implementation & Validation Plan

Based on the simulation results, a phased implementation of the optimized strategy is the recommended path to value realization. The initial phase should focus on tracking real-world performance against simulation predictions over a 12-month period.

Key metrics include:

- Failure frequency by mode
- Emergency vs. planned maintenance cost
- Production availability
- Actual Total Cost of Ownership

This data collection process enables a future validation study to confirm forecast accuracy and quantify the realized financial outcomes.

6. Limitations & Risk Considerations

Assumption Sensitivity

TCO values are sensitive to downtime cost assumptions. A ±50% change in downtime valuation shifts absolute results but does not alter strategy ranking. Sensitivity analysis confirms the robustness of conclusions.

Implementation Risk

Savings depend on execution discipline, inventory readiness, and production coordination. These risks are mitigated through structured change management and pilot rollout.

Data Quality Dependency

Model accuracy depends on CMMS data completeness and consistency. This analysis was made possible by a substantial and high-quality dataset **spanning nearly a decade** of historical records.

Model Scope

Aggregated failure modeling supports executive decision-making but does not replace detailed engineering analysis for component-level design decisions.

7. Conclusion & Commercial Offering

This case study demonstrates that simulation-based financial modeling can transform maintenance from a cost center into a quantified investment decision.

Pilot Engagement Offering

Duration: 4–6 weeks
Client Input: Historical maintenance data (under NDA) and limited stakeholder time
Deliverables:

- Failure mode and cost concentration analysis
- Reliability digital twin
- Multi-scenario financial simulations
- Executive-ready optimization report

About Ratotecki

Ratotecki is a technology company focused on financial optimization of industrial asset strategies. Our Jingongo platform enables organizations to evaluate maintenance and capital decisions through simulation rather than intuition.

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References

1. Reliability Academy explains that many preventive maintenance tasks *“add little value”* because they are duplicated, too frequent/too infrequent, or don’t address actual failure modes — and notes that **40 – 60 % of PM tasks can be low value** in typical programs.
   URL: https://reliabilityacademy.com/preventive-maintenance/
2. A related Reliability Academy article *“Is your preventive maintenance even worth doing?”* states that **up to ~60 % of PM tasks may not add value**, taking time and money without improving reliability.
   URL:
   https://reliabilityacademy.com/articles/preventive-maintenance/is-your-preventive-maintenance-even-worth-doing
3. Reliability-centered maintenance principles explain that for a large share of failure modes, time-based maintenance doesn’t improve reliability — suggesting that many time-based PM activities are not effective for those failure patterns.
   URL:
   https://reliabilityacademy.com/articles/preventive-maintenance/reliability-centered-maintenance-principles